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# LARVAL PARASITISM OF *RHAGOLETIS COMPLETA* (DIPTERA: TEPHRITIDAE) ON *JUGLANS MICROCARPA* (JUGLANDACEAE) IN WESTERN TEXAS AND SOUTHEASTERN NEW MEXICO

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*Abstract.*—Two hymenopterous parasitoids, *Biosteres sublaevis* Wharton (Braconidae) and *Trybliographa* sp. (Cynipidae) caused varying degrees of natural parasitism on *Rhagoletis completa* Cresson in western Texas and southeastern New Mexico during four survey years, 1978, 1980, 1981, and 1983. A "killing-power" analysis in 1980 indicated a significant ($P \leq 0.05$) impact of combined natural mortality on host reduction. *Biosteres sublaevis* demonstrated the greatest measureable activity as a cause of natural mortality.

The walnut husk fly, *Rhagoletis completa* Cresson, has been a pest of Persian walnut, *Juglans regia* L., in California since 1926 (Boyce, 1934). It initially invaded a walnut orchard at Chino in southern California in 1925 (Michelbacher and Ortega, 1958; S. E. Flanders, pers. commun.). The founders of the California population may have originated in western Texas (Berlocher, 1976). Natural enemy activity on this species in wild and cultivated *Juglans* species in California has been negligible in California (Boyce, 1934; E. F. Legner, unpublished data).

We were told of a high incidence of larval parasitism of this species by an opiine braconid in its native range in the Davis Mountains of western Texas in 1974 (S. H. Berlocher, pers. commun.). This report details field collections of *R. completa* larvae and subsequent measurement of parasitoid activity throughout this area during 1978–1983.

## METHODS AND MATERIALS

*Rhagoletis completa* is a univoltine species in western Texas that attacks ripening fruit of so-called "little walnut," *Juglans microcarpa* Berlandier, following late-summer rains. Larvae can only be obtained in fruit during a short period during mid August and early September (S. H. Berlocher, pers. commun.; E. F. Legner, unpub. data). Most fruit drop from trees by the second week of September and the larvae immediately exit from the fallen fruit and enter the ground to pupariate.

Surveys were conducted on *J. microcarpa* from near Carlsbad, New Mexico throughout the Davis Mountains of Texas and south to the northern boundary of Big Bend National Park (Table 1). This region lies within the Chihuahuan Desert between the Rio Grande and Pecos Rivers and has many prominent mountains which usually support a grassland climax vegetation (Warnock, 1970). *Juglans microcarpa* is a common tree along arroyos at elevations between 1200 and 1600 m.

Samples of whole, blackened infested walnuts were taken from trees during the final week of August in 1978, 1980, 1981 and 1983. However, all sites could not be sampled each year because the fruit had fal-

Table 1. Sample sites of *Rhagoletis completa* Cresson on *Juglans microcarpa* in western Texas and southeastern New Mexico during 1978–1983.

| Site No. | No. Trees Sampled | Km & Direction from Ft. Davis, TX | Location |
|---|---|---|---|
| 1 | 20 | 4 NE | Rt. 17, NE of Ft. Davis, TX |
| 2 | 10 | 4 N | Along Hwy. 118, N of Ft. Davis (Kent Rd.), TX |
| 3 | 10 | 7 N | Indian Lodge (adjacent to buildings), TX |
| 4 | 15 | 5 N | Indian Lodge (camping area) |
| 5 | 9 | 13 NE | Route 17, NE of Ft. Davis, TX |
| 6 | 10 | 24 S | North of Alpine, TX in canyon on Rt. 118 |
| 7 | 1 | 28 N | Rt. 118, 2.5 km N of McDonald Observatory Rd., TX |
| 8 | 6 | 38 NE | Along Rt. 17, 13 km S of Toyahvale, TX |
| 9 | 10 | 40 NW | Rt. 118, Madera canyon picnic area, TX |
| 10 | 5 | 48 W | Rt. 166, W slope of Davis Mts., TX |
| 11 | 6 | 53 N | Hwy. 118, N of Ft. Davis, TX |
| 12 | 5 | 70 N | Hwy. 118, N of Ft. Davis, TX |
| 13 | 5 | 74 S | North of Big Bend Natl. Park, Hwy. 118, TX |
| 14 | 8 | 243 NW | Rattlesnake Springs, Guadalupe Mts., NM |
| 15 | 10 | 275 NW | Carlsbad Natl. Park, NM |

len prior to our arrival. Fruit fall depended on variable weather conditions (wind and rainfall). An estimate of larval density per walnut was made in 1980 by sampling 300 walnuts at random per tree. Walnuts were placed on 4 cm of local soil in polyethylene buckets for 5 days to allow larvae to exit the nuts and pupariate in the soil. Puparia were then carefully and with minimum abrasion sifted from the soil and placed in 12 dram screened polystyrene containers. The caged puparia were transported to Riverside and placed in quarantine at the University of California, where they were stored in refrigerators at 3° ± 1°C and 55% RH for 6 months. They then were incubated at 25° ± 1°C, 55% RH and a 14:10 h L:D photoperiod to allow emergence of adult flies and parasitoids. Unemerged puparia were refrigerated for another 6 months beginning the following September, followed by another period of incubation to promote additional emergence. A third such refrigeration/incubation cycle also was performed.

Identifications.—The identity of *Rhagoletis completa* was verified by comparing adult specimens with those identified for the Department of Entomology by F. L. Blanc and R. H. Foote, and by referring to the descriptions in Boyce (1934) and Michelbacher and Ortega (1958). The *Trybliographa* sp. was identified by G. Gordh.* *Biosteres sublaevis* Wharton was identified by R. A. Wharton from material we gave K. Hagen, some of which probably were included in Wharton's type series. We identified subsequent collections of *sublaevis* by reference to Wharton and Marsh (1978).

Statistical analyses.—Larval walnut huskfly densities per walnut at the time of initial field sampling were compared to the final densities after parasitization and other mortality factors had acted. These density differences measured parasitoid response to varying host densities in the field and determined whether such response was regulative, i.e. an increasing proportion of hosts were parasitized at higher host densities. First, the initial larval density in 300 sampled walnut fruit per tree was compared to the parasitized host density using a bivariate correlation analysis. Secondly, host regu-

* Voucher specimens are deposited in the Department of Entomology, University of California, Riverside.

Table 2. Emergence of *Biosteres sublaevis* and *Tribliographa* sp. parasitoids from *Rhagoletis completa* puparia collected as larvae in the Davis and Guadalupe Mountains of western Texas and southeastern New Mexico during 1978–1983.

| Site | Year | No. Puparia Obtained | No. Adult Flies Emerged | % Puparia from which Nothing Emerged | No. *Biosteres* emerged[1] | | | No. *Trybliographa* Emerged[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ♀♀ | ♂♂ | % Parasitism | ♀♀ | ♂♂ | % Parasitism |
| 1 | 1978 | 7812 | 3953 | 28.4 | 752 | 891 | 29.4 | 0 | 0 | 0 |
| | 1980 | — | — | — | — | — | — | — | — | — |
| | 1981 | — | — | — | — | — | — | — | — | — |
| | 1983 | 1358 | 251 | 77.1 | 0 | 20 | 6.4 | 22 | 18 | 12.9 |
| 2 | 1978 | 2855 | 654 | 45.3 | 323 | 584 | 58.1 | 0 | 0 | 0 |
| | 1980 | 700 | 310 | 42.9 | 60 | 30 | 22.5 | 0 | 0 | 0 |
| | 1981 | 823 | 93 | 81.3 | 21 | 40 | 39.6 | 0 | 0 | 0 |
| | 1983 | 480 | 10 | 93.8 | 10 | 10 | 66.7 | 0 | 0 | 0 |
| 3 | 1978 | 3271 | 740 | 30.8 | 803 | 722 | 67.3 | 0 | 0 | 0 |
| | 1980 | 1320 | 680 | 35.6 | 100 | 70 | 20.0 | 0 | 0 | 0 |
| | 1981 | 474 | 44 | 87.3 | 8 | 8 | 26.7 | 0 | 0 | 0 |
| | 1983 | 1047 | 313 | 59.7 | 39 | 66 | 24.9 | 2 | 2 | 0.9 |
| 4 | 1978 | 2961 | 410 | 30.1 | 751 | 910 | 80.2 | 0 | 0 | 0 |
| | 1980 | 1233 | 692 | 28.9 | 102 | 83 | 21.1 | 0 | 0 | 0 |
| | 1981 | 2391 | 112 | 91.4 | 31 | 62 | 45.4 | 0 | 0 | 0 |
| | 1983 | 3250 | 1080 | 55.4 | 300 | 50 | 24.2 | 11 | 8 | 1.3 |
| 5 | 1978 | — | — | — | — | — | — | — | — | — |
| | 1980 | 361 | 162 | 46.8 | 20 | 10 | 15.6 | 0 | 0 | 0 |
| | 1981 | 419 | 21 | 90.5 | 10 | 9 | 47.5 | 0 | 0 | 0 |
| | 1983 | 290 | 180 | 37.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 1978 | 441 | 322 | 27.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1980 | 383 | 222 | 33.9 | 31 | 0 | 12.3 | 0 | 0 | 0 |
| | 1981 | 611 | 21 | 94.9 | 0 | 10 | 32.3 | 0 | 0 | 0 |
| | 1983 | 1661 | 148 | 89.2 | 11 | 0 | 6.1 | 12 | 8 | 11.2 |
| 7 | 1978 | 1658 | 693 | 19.5 | 291 | 351 | 48.1 | 0 | 0 | 0 |
| | 1980 | 1930 | 1440 | 20.2 | 90 | 10 | 6.5 | 0 | 0 | 0 |
| | 1981 | 681 | 23 | 96.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1983 | 571 | 55 | 90.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 1978 | 580 | 50 | 27.6 | 250 | 120 | 88.1 | 0 | 0 | 0 |
| | 1980 | 273 | 174 | 36.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1981 | 349 | 50 | 82.5 | 0 | 11 | 18.0 | 0 | 0 | 0 |
| | 1983 | 369 | 0 | 100.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 1978 | 517 | 85 | 30.0 | 139 | 138 | 76.5 | 0 | 0 | 0 |
| | 1980 | 1072 | 822 | 23.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1981 | 763 | 42 | 93.1 | 11 | 0 | 20.8 | 0 | 0 | 0 |
| | 1983 | — | — | — | — | — | — | — | — | — |
| 10 | 1978 | — | — | — | — | — | — | — | — | — |
| | 1980 | 161 | 62 | 61.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1981 | 378 | 35 | 90.2 | 0 | 2 | 5.4 | 0 | 0 | 0 |
| | 1983 | — | — | — | — | — | — | — | — | — |
| 11 | 1978 | — | — | — | — | — | — | — | — | — |
| | 1980 | — | — | — | — | — | — | — | — | — |
| | 1981 | 2821 | 279 | 89.4 | 20 | 0 | 6.7 | — | — | — |
| | 1983 | — | — | — | — | — | — | — | — | — |
| 12 | 1978 | 720 | 80 | 30.6 | 240 | 180 | 84.0 | — | — | — |
| | 1980 | 323 | 182 | 43.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1981 | — | — | — | — | — | — | — | — | — |
| | 1983 | — | — | — | — | — | — | — | — | — |

Table 2. Continued.

| Site | Year | No. Puparia Obtained | No. Adult Flies Emerged | % Puparia from which Nothing Emerged | No. *Biosteres* emerged[1] | | | No. *Tribliographa* sp. Emerged[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ♀♀ | ♂♂ | % Parasitism | ♀♀ | ♂♂ | % Parasitism |
| 13 | 1978 | 576 | 387 | 29.2 | 21 | 0 | 5.1 | 0 | 0 | 0 |
| | 1980 | 270 | 160 | 40.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1981 | — | — | — | — | — | — | — | — | — |
| | 1983 | 349 | 181 | 48.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 1978 | — | — | — | — | — | — | — | — | — |
| | 1980 | 2930 | 750 | 65.5 | 110 | 140 | 24.8 | 6 | 4 | 1.0 |
| | 1981 | 343 | 0 | 100.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1983 | — | — | — | — | — | — | — | — | — |
| 15 | 1978 | 203 | 37 | 28.6 | 58 | 50 | 74.5 | 0 | 0 | 0 |
| | 1980 | 1322 | 923 | 30.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1981 | — | — | — | — | — | — | — | — | — |
| | 1983 | — | — | — | — | — | — | — | — | — |

[1] % parasitism = no. emerged parasitoids/total emerged parasitoids + hosts × 100.

lative response was analyzed by correlating the $\log_{10}$ (initial density + 1.0) with the difference between $\log_{10}$ (initial density + 1.0) and the $\log_{10}$ (final density + 1.0), i.e. the "killing power" or "k-value" of Varley et al. (1974). Correlation coefficients were all tested at $P \leq 0.05$.

Determination of a parasitoid's activity from incubation and emergence data in the laboratory, however, may underestimate its actual impact. Some hosts may be killed by the probing and oviposition of parasitoids, and die without giving rise to adult parasitoids as suspected previously for other insects (Legner, 1979; Legner and Silveira-Guido, 1983). Also, although considerable care was taken to provide a natural situation for pupariation, and handling was done as little as possible, some developmental anomalies may have occurred during the pupal stage. These may result in adult emergence failures.

## Results and Discussion

Adults of only *R. completa* emerged from the nuts collected, although *Rhagoletis juglandis* (Muesebeck) is known to occur in the northwestern portion of the study area (sites 14 and 15).

The first refrigeration/incubation cycle stimulated >95% of the total emergence of host flies and parasitoids in every sample (Table 2). *Biosteres sublaevis* was the most prominent parasitoid species reared. *Trybliographa* sp. occurred at much lower frequencies, and always in conjunction with the former species. Parasitism was widespread throughout the sampled area and varied considerably from year to year at any given site (Table 2). There may have been a trend toward higher parasitism in areas protected from the full impact of storms from the north by rises of the Davis and Guadalupe Mountain ranges, whereas in the more-open, northernly exposed and windswept areas, e.g. 10, 11 and 13 (Tables 1 and 2), parasitism was comparatively lower. Site 12 was sheltered by the northernmost foothills of the Davis Mountains and showed relatively high parasitism.

High mortality in puparia also was recorded at all collection sites (Table 2). This mortality was not correlated with intensity of parasitoid emergence ($r = -0.186$, 41 df), and probably was caused by combinations of handling, parasitoid probing and aborted parasitism.

There was a significant correlation between the initial within walnut larval density and the final adult fly emergence density in 1980 (r = 0.777, 14 df). A subsequent k-value analysis (Varley et al., 1974) also showed a significant correlation (0.494, 14 df). This indicated that fly mortality from all natural factors combined occurred in greater proportions at relatively higher initial larval densities. However, it cannot be ascertained whether parasitism was the main regulative factor, because there was no significant correlation between the initial host larval density and the *Biosteres* density (r = 0.308, 14 df). Data pertaining to inter-tree and -walnut density might give further clues to the regulative ability of the parasitoids. However, problems associated with measuring the full impact of any parasitoid on its host in the wild reviewed recently (Legner, 1983; Legner and Silveira-Guido, 1983) obviously also contributed to our inability to access this natural parasitism more fully.

The wide distribution and high intensity of walnut husk fly larval parasitization by *B. sublaevis* in the surveyed areas has prompted an effort to introduce this species into California from Texas for biological control.

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